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11 Guidance on recording palaeopathology (abnormal variation)

Charlotte Roberts and Brian Connell

This is the extended and totally revised version of Chapter 11 of Brickley M, McKinley J (eds) 2004 *Guidelines to the standards for recording human remains.* Reading, Institute of Field Archaeologists Paper Number 7.

The two-page addition to that chapter in the 2nd edition of the guidance did not allow for the number of revisions the first author felt was needed.

> 'Few published data sets were directly comparable (and) ... no single report offered comprehensive data' (Buikstra and Ubelaker 1994, 3).

11.1 Introduction

The science of biological anthropology encompasses many different disciplines, including bioarchaeology. One of the major themes within bioarchaeology is the study of patterns of disease in past populations (palaeopathology) have – Roberts and Manchester 2005. This includes studying evidence of disease in the bones and teeth of archaeological skeletons, the soft tissues of preserved bodies, but also parasite eggs found with bodies, from soils of graves containing skeletons, and also archaeological contexts such as latrines and cesspits. The type of studies in palaeopathology have evolved and to a certain extent changed away from single case study approaches towards viewing bioarchaeological data from larger groups of skeletons in a wider cultural context (e.g. Jurmain 2001). However, in more recent years there has been a return to "case studies" of individual skeletons through biomolecular research (e.g. ancient DNA analysis; studies of only single skeletons or bodies are often due to the cost of this analysis), and as a result of the publication of the "Index of Care" (Tilley and Cameron 2014). However, individual "case studies" remain a popular publication in palaeopathology and of course can contribute to syntheses of large datasets (e.g. see Roberts and Cox 2003). While there are many different types of evidence for considering health in past populations, including historical and iconographic representation particularly in historical periods, human remains from archaeological sites provide the primary source of data.

Mays (1997; 2010; 2012a) has also noted the emergence of broader synthetic work in palaeopathology, and suggests that studies of human remains should be directed at answering specific archaeological questions, in addition to pursuing particular themes about the past (e.g. diet and economy), and/or testing hypotheses (Roberts 2009:164-189). One key area of this exercise involves examining the role that disease has played in the complex process of human groups adapting to their environments (Ortner 1991). This should potentially allow us to consider the population dynamics of disease and to investigate patterns and trends in human adaptation in the past. It is important that future studies in palaeopathology are underpinned with comparable datasets that allow

inter-population comparisons. The mechanism by which this can be achieved is by establishing a commonly accepted set of standard methods for basic skeletal and dental pathology recording. Human skeletal reports undertaken as part of commercial projects are especially vital in providing data and ideas for future investigations.

The standardization of pathological data recording is by no means a straightforward exercise. It can be difficult to encourage different researchers with different agendas and commitments to the study of ancient disease to agree which data should be recorded how and why. It is accepted that researchers often have their specific research objectives, which include recording methods that may go beyond the basic recording often carried out in commercial contexts. However, in general, the quality and quantity of data recorded still varies considerably and, as Larsen (2015, 2) points out, the standardization of data collection from human remains remains a complex and debated issue.

Stimulated by the prospect of repatriation of human remains and their potential reburial in North America in the late 1980s, the first steps towards standardization of recording in palaeopathology were taken (Rose *et al* (1991), who suggested a series of objective criteria based on description. This was followed by a seminar of key bioarchaeologists and a more comprehensive set of recommendations made by Buikstra and Ubelaker (1994). The latter currently stands as the most commonly accepted set of recording standards and forms the basis for the present (BABAO) document. While reburial of human remains in the UK is not (currently) the stimulus to this document, it is becoming more relevant. Despite the foregoing discussion, palaeopathological studies of past British populations need to establish recommendations for recording of data such that the discipline of palaeopathology advances and becomes more scientifically valid.

The aim of this section is to:

- Review the methods currently in use for recording pathological lesions in human skeletal remains.
- Make some recommendations to guide those who are working in palaeopathology. This is particularly important for commercial archaeology projects where time and money may be limited
- Recording of parasite eggs is the focus of another section in the BABAO standards document

11.2 Recording of pathological lesions: the language of description

‘Accurate and comprehensive descriptions of pathological lesions are necessary for accurate diagnoses and also permit other researchers to evaluate proposed diagnoses’ (Lovell 2000, 219).

Ortner (2003, 48) suggests that there are three essential elements for recording

skeletal pathology:

1. Unambiguous terminology

2. Precise identification of the position of lesions in/on abnormal bones/teeth

3. A descriptive summary of the morphology of abnormal bones/teeth

The basic premise for recording pathological lesions should be a detailed description of the abnormal lesions, prior to any suggestion of differential diagnoses. In undertaking this primary description, the language must be simple and non-technical, and if any technical terms are used then they should be clearly defined, perhaps in a glossary of terms. Buikstra and Ubelaker (1994, 108) stress the importance of clear, consistent and unambiguous terminology and the hazards associated with the use of non-standard terminology. In order to obtain some form of acceptable standard terminology, the terms suggested by Lovell (2000, 221) could be used as a baseline. As Buikstra and Ubelaker (1994, 107) state, 'the goal of the following data collection protocol is not to lead the observer to a specific disease diagnosis, but rather to encourage data collection sufficient for future scholarship...'.

There are four key methods used for recording pathological lesions: macroscopic, radiological, histological and biomolecular. Most bioarchaeologists use macroscopic observation, sometimes supplemented with radiology, both in a commercial and an academic environment. Histological and biomolecular methods are used less frequently because of costs and access to facilities, but the latter are increasingly being utilized. Useful references for these methods include Turner-Walker and Mays (2008), Mays (2008a), Brown and Brown (2010)

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Lovell (2000, 219) suggests that due consideration should be given to: appearances of pathological lesions, their position on a bone or tooth, and the distribution of lesions in the skeleton, alongside considering the socio-cultural context and time period from which the population derives. Note, that certain diseases are more common in specific regions of the world, and even in specific regions of countries. This may affect what diseases may be seen. By considering the presence and distribution pattern of the abnormal lesions, a differential diagnosis (or several possible diagnoses) may be made. Noted is the study by Miller et al (1996) who observed in their study that practitioners were more comfortable with diagnosis of a "category" of disease, such as joint disease, rather than a specific disease category (e.g. rheumatoid arthritis).

The description of pathological bone changes based on visual observation is, for most, a macroscopic exercise. However, it is recommended that descriptions be supported with low-power microscopic examination (e.g. x10 magnification) and

radiography wherever possible. The following is suggested as a step-by-step procedure in description.

It should be noted that comparison of abnormal with normal bones and teeth is a pre-requisite to recognizing the abnormal, and access to a disarticulated comparative skeleton is considered essential for this work, along with an excellent knowledge of the normal appearance of the bone or tooth. Only *definite* abnormalities that are not a result of what can be normal variation, pseudopathology, or postmortem damage should be recorded so as not to over-inflate prevalence rates for disease. However, lesions that are the result of normal variation, pseudopathology, or postmortem damage should be recorded in the general description:

1. Which bone/tooth is affected (including side)?

2. What part of the bone/tooth (e.g. proximal shaft and crown, respectively), and aspect (e.g. medial and lingual, respectively), is involved, using anatomical terms (also see Lovell 2000, Table 8.2 for terms)?

3. What is the nature of the lesion itself (see Lovell 2000, Table 8.1 for terms)? Is it a bone forming, destroying, or mixed lesion, and with respect to dental and alveolar bone disease: is there destruction of the tooth structure, or destruction of the alveolar bone (e.g. periapical lesion, periodontal disease)

4. If bone has been formed, is it woven (porous, disorganized and indicating active disease at the time of death) or lamellar (smooth and organized), indicating a healed and chronic lesion, or is it in the process of healing? See Figures 12 and 13.

5. If bone has been destroyed, is there any sign of healing e.g. rounding of the edges of the lesion (see Figure 14); see also Figures 15 (unhealed, perimortem lesion), Figure 16 (postmortem damage), and Figure 17 (destructive lesions with some new bone formation repair and remodelling

6. What is the distribution pattern of the lesions if more than one bone/tooth is involved? Different disease processes have different skeletal patterning (for example, leprosy affects the facial, hand and foot bones).

7. Can the abnormality be measured and compared with the normal opposite side (e.g. a fractured versus normal femur); what is the area affected on the bone e.g. new bone formation or destruction?

8. Consider all potential diagnoses for the abnormalities recorded (differential diagnosis); that is, use clinical data to appreciate which diseases could have caused the bone changes observed, bearing in mind that clinical data may not always be appropriate (Mays 2012b).

Figure 12 Woven new bone formation (arrowed) on long bone shaft

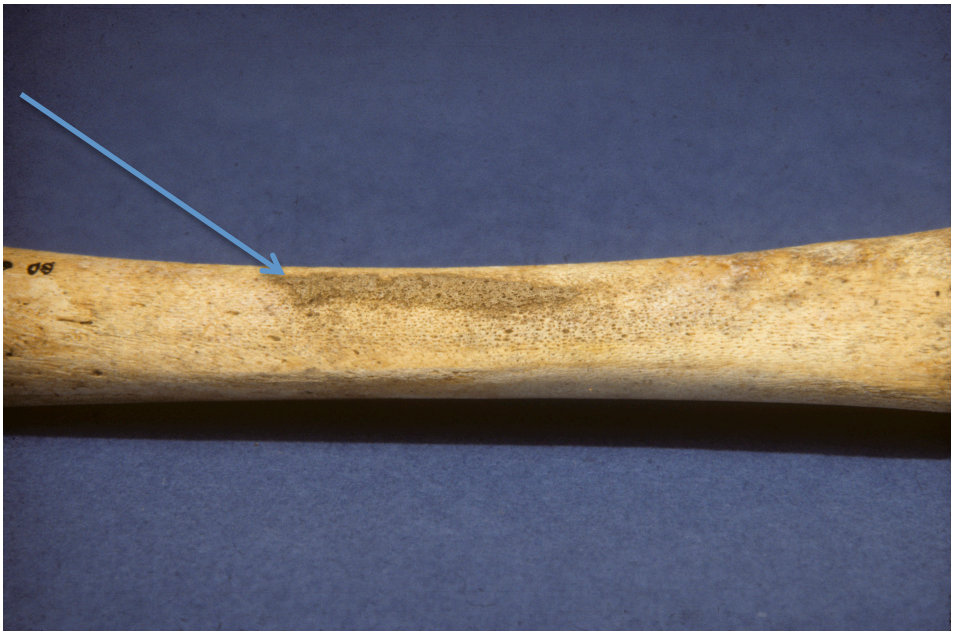

Figure 13 Lamellar new bone formation on tibia and fibula

Figure 14 Healed injury to cranium; smooth rounded and remodeled edges

Figure 15 Unhealed (perimortem) injury to the cranium; no evidence of healing

Figure 16 Perimortem "wound" to the cranium; note white edges to the lesion

Figure 17 Destructive lesions to the cranium, with some healing and remodeling

It is absolutely essential that any description thus given should allow for independent review by another observer who can, based on an objective

description, agree or disagree with the preferred diagnosis. This should also help ensure comparability across skeletons from the same sites, and between populations.

Photographs of abnormal or rare lesions are recommended, especially if they are unusual and a diagnosis made is rather tenuous; this will help other researchers when the abnormalities are being reconsidered or if the skeleton has been reburied. Photographs should also be taken if the "severity" of lesions are being described, although note that intra- and inter-observer error may be introduced using this recording process. Scales should be used and preferably a normal bone or tooth as a comparison (or opposite side if appropriate and preserved). Black backgrounds are often an effective contrast for displaying bones, teeth and their respective lesions for photography, and filling most of the frame with the bone or tooth provides a more informative illustration. When radiography is used, descriptions should include the relationship of the lesion to the underlying cortex, endosteal changes and/or changes in the medullary cavity.

Detailed descriptions of pathological lesions in human remains should be available for future use, being archived electronically for download, in an ideal situation.

11.3 Coding of lesions

Buikstra and Ubelaker's (1994) extensive and detailed recording system of individual bone and pathology codes, followed by side, section and aspect affected, followed again by more coding of pathology, is somewhat cumbersome and restrictive to be of practical use in most cases (especially in commercial archaeology). For example, a right ulna with a healed parry fracture would be coded as follows: (1), (3), (9), (4.1.3), (5.1.3). The aspects of the pathological lesions represented by these codes should already have been covered in the descriptive process, and the code numbers do not represent quantitative data. Bioarchaeologists could become too involved with assigning multiple codes rather than focusing on clear unambiguous description.

11.4 Problems and limitations

Diagnosis with the aid of clinical literature

Because reaching a secure diagnosis is often very difficult, some bioarchaeologists advocate interpreting all data from a clinical base (e.g. Roberts and Manchester 2005), and a good recommended reference is Resnick (2002). Some are more cautious with this approach and Ortner (1991, 6) warns against an over-reliance on clinical diagnostic criteria; Mays (2012b) is also a useful reference on this matter. Miller *et al* (1996) have pointed out that in palaeopathology it may only be the areas of the skeleton with obvious pathological changes that are radiographed, or that data on pathological lesions derived from clinical sources might represent a milder expression of a serious

disease than would be found in those individuals without access to medical intervention. These factors can limit the palaeopathological usefulness of descriptions of diseases in modern clinical literature (Miller *et al* 1996, 224). When a bioarchaeologist examines a skeleton that displays pathological alteration one of the other problems faced is the level of accuracy associated with a "diagnosis", which can often be limited due to being unable to assess soft tissue changes, or the inability to reliably apply immunological tests when compared to diagnosis in living people (Waldron 1994:36-37).

Other problems may arise from the fact that many of the more subtle changes apparent on dry bone will not be part of the experience of the radiologist today, and thus not be part of the radiological descriptive and classificatory system (Ortner 1991, 8). Clearly, some clinical diagnostic criteria are inappropriate for archaeologically derived skeletal remains, and some pathological changes may not be noted clinically e.g. bone formation on the visceral surfaces of ribs or in the maxillary sinuses (lower and upper respiratory tract disease, respectively – Roberts et al 1994; Roberts 2007). It is clear that, whatever the case, clinical comparisons should be chosen with caution. Clinical data from patients experiencing bone disease in developing countries (the most analogous to an archaeological context) may be more useful in this respect. For example, in this case the manifestation of disease in bone will not necessarily have been altered by the influence of drug therapy, such as antibiotics to treat infections (i.e. the disease may be untreated), and environmental and sociocultural factors may be similar.

Despite these problems, the only way to attempt any form of classification or diagnosis of disease in skeletal remains is with clear and objective description. It is only with this baseline description that a potential diagnosis can be made. Please also note that palaeopathological and clinical texts often illustrate the most chronic and severe expressions of the disease; it should be remembered that chronic skeletal lesions do not develop "overnight" and there is a development in progression of a disease in bones or teeth perhaps over several months or years. The stage at which the effect of the disease on the skeleton has reached at the time of death of the person will vary.

Biomolecular diagnosis

The recent developments in the use of extracted microbial ancient DNA, disease specific proteins, and other biomolecules, such as mycolic acids, to diagnose disease has been a major development in palaeopathology (e.g. see Salo *et al* 1994; Müller et al 2014, Schuenemann et al 2013, Bos et al 2011), despite inherent methodological problems (see Brown and Brown 2010). However, it should be noted that a positive result for the presence of a particular pathogen's ancient DNA does not necessarily mean that the disease caused the bone changes of interest. Nevertheless, for those with access to these types of analyses there are clear advantages (for example, looking at strains of pathogens, and susceptibility and resistance genes, or diagnosis of disease that

only affects the soft tissues). However, sampling for ancient DNA and other biomolecules for disease diagnosis should only be undertaken when a full skeletal analysis of the skeleton concerned has been undertaken, and the questions being asked cannot be answered in any other way. The possibility that aDNA may not be preserved in the remains of interest should also be considered. Further information and guidance on bone chemistry can be found in the BABAO standards document, and also in http://www.archaeologyuk.org/apabe/Science_and_the_Dead.pdf.

…And finally….

Three further points need noting here.

Firstly, bioarchaeologists should be aware of the possible effects of burial in the ground on the integrity of skeletal remains (taphonomic factors), and the possibility that abnormal changes to bones and teeth may be the result of post mortem damage, such as root marks, rodent gnawing, deformation through soil pressure in the grave, and erosion from the soil (Buikstra and Ubelaker, 1994 Figures 68–73, Wells 1967). In addition, pseudopathological lesions may be confused with normal features of the skeleton such as pacchionian pits on the endocranial surface of the skull, normal blood vessel markings (knowledge of normal anatomy here is essential), new bone formation as a result of the normal growth and remodelling processes in bones of juvenile skeletons, and the presence of non-metric traits. It is essential that the preservational state of the skeleton is recorded (completeness of the skeleton, level of fragmentation, and condition of the bone surfaces); this has implications for what pathological conditions may be recorded and whether distribution patterns of lesions can be documented. For example, the recording of surface inflammatory changes of eroded bones and joint disease of poorly preserved joint surfaces will be compromised.

Secondly, researchers should note that, as bone can only react in a limited number of ways to a disease stimulus (form/destroy bone), there can be several different processes that could potentially induce the observed result, and these must be given full consideration in the differential diagnosis (Ortner 2012).

Finally, if what might be interpreted as “severity” of bone or dental changes are to be recorded, potential intra- and inter-observer should be considered (and error tests should be conducted to ensure consistency in recording), and that a greater “severity” of bone changes does not necessary correlate with worse symptoms, e.g. increased pain (e.g. see Riddle et al 1988). When recording “severity or extent” of lesions the reason for doing so should be considered: what does this tell us? Recording presence or absence is a safer route to follow.

11.5 Specific disease processes

It has been stressed that detailed descriptions of pathological lesions are essential. These descriptions and/or potential diagnoses should be supported using the most up to date and appropriate literature. There are several well-established methods for recording and describing the more commonly encountered disease processes in archaeologically derived human remains; these are covered in Section 11.7. However, in this short chapter it is not possible to cover all eventualities and readers should consult relevant texts and papers, as appropriate.

11.6 Congenital/developmental abnormality

Barnes (2012) gives an excellent summary of most of the congenital/ developmental defects that occur in the axial skeleton, such as border shifts (e.g. L5 sacralisation, S1 lumbarisation, C1 occipitalisation), segmentation errors (e.g. hemivertebrae, segmentation failures (fusion) and developmental defects (e.g. spina bifida occulta, hypoplasia, aplasia etc). Turkel (1989) is also useful.

11.7 Specific disease processes

11.7.1 Infectious disease

Non-specific infection: All bone changes attributed to infection should clearly state the extent to which the structure of the bone affected is involved in *non-specific infection*, e.g. periostitis, osteomyelitis (presence of cloaca – sinus or hole, sequestrum – dead bone, and involucrum –sheath of new bone) and osteitis. Specific areas of the skeleton affected should also be observed for non-specific infection: maxillary sinuses, if broken post mortem and therefore visible (use Boocock *et al*'s 1995 classification), ribs (see Roberts *et al* 1994), and the endocranial surface of the skull (see Lewis 2004).

Specific infection (where the infection causing organism is know): treponemal disease, tuberculosis, leprosy; recording of pathological changes in bones and teeth due to these specific infections should clearly state which diagnostic criteria have been used. We would recommend the following in addition to Ortner (2003) and Aufderheide and Rodríguez-Martín (1998):

• Leprosy: Andersen *et al* (1992; 1994), Andersen and Manchester (1987; 1988; 1992), Lewis *et al* (1995)

• Tuberculosis: see Roberts and Buikstra 2003 for an overview

• Treponemal disease: Hackett (1976)

11.7.2 Trauma (see Bennike 2008)

(i) Fractures

Record:

• bone affected

• part of bone

• type of fracture (spiral, comminuted, transverse, oblique, greenstick, compression (e.g. vertebrae), depressed (e.g. cranial); see also Novak (2000) on types of cranial injuries, and Boylston (BABAO standards)

• the probability of it being simple or compound

• evidence of healing

• evidence of complications, e.g. non-union, pseudoarthrosis, necrosis or death of bone, secondary complications such as infection and joint disease –care should be taken in determining whether these bone changes occurred pre- or post-fracture

<u>For long bones fractures</u>

• angular or spiral deformity

• apposition of the fracture fragments

• amount of overlap

Lovell (1997) is also useful. For recording radiographs of fractures see Roberts (1988) and Grauer and Roberts (1996).

(ii) Dislocation

Record joint affected and any changes to the joint surfaces, including a new joint surface development; is the dislocation congenital or traumatically induced? Any associated fractures?

(iii) Soft tissue injury

Record area of bone affected and link to muscle (myositis ossificans), tendon/ligament attachments and their actions.

(iv) Other

Spondylolysis: Separation of the neural arch of the lumbar vertebra (usually L5), with or without slipping forward of the vertebra (spondylolisthesis); is it unilateral or bilateral, are there any other associated defects, and is there any evidence of healing?

Amputation: bone element affected, any evidence of healing, any evidence of difference in size of bones affected and not affected (possible disuse atrophy/wasting)

Trepanation: type (scrape, saw, bore and saw, gouge, drill), position on the skull, healed or not, evidence for head injury.

Autopsy: for craniotomy record angle, position and precision of saw cut (number of attempts) and whether the occipital bone is included, or merely the frontal and parietal bones. For sawn long bones, if possible, a distinction should be made between possible practice amputation and evidence for anatomical specimen preparation.

11.7.3 Joint disease

Joint disease is one of the more common pathological conditions found in skeletal remains. This comprises mostly osteoarthritis (synovial joints of the body). NB: If osteoarthritis is being used as a possible indicator of lifestyle/occupation, other indicators such as entheseal changes (tendon and ligament attachments), differences in the size of left and right bones, other pathological lesions and some non-metric traits should also be considered (see Jurmain 1999; see also Tyrrell 2000). Osteoarthritis should never be used alone as an indicator of occupation because of its multifactorial aetiology, especially increasing age. There is a wealth of literature on this subject matter.

Any joint changes should be recorded according to joint affected and location on the joint. The work of Rogers and Waldron is particularly useful here and it is recommended that their diagnostic criteria are used (Rogers *et al* 1987; Rogers and Waldron 1995). A diagnosis of osteoarthritis should only be made if eburnation exists or, if not, two other bone changes, for example porosity and osteophytes. Osteophytes alone may purely be a sign of the ageing process and should not be used for a diagnosis of osteoarthritis.

Osteophyte formation on, or around the margins of joint surfaces, **porosity** of the joint surface, **subchondral/ subarticular cysts** (seen using radiography), **eburnation** (polishing), **erosive lesions**, and **fusion** of the bones of joints are all features of joint degeneration. It should also be noted that in British skeletal populations, the formation of bone can be common at tendon, ligament and muscle attachment sites (entheseal changes), and may be associated with joint disease (“bone formers”); this should not be not necessarily be inferred as bone formation as a result of activity.

It is important to describe the type of osteophytes that have formed at joints, because different types are associated with various conditions (refer to Rogers and Waldron 1995, Table 3.1). The site of the osteophytes, porosity, eburnation on the joint should be recorded, along with the position of erosive lesions (on the joint surface, next to the joint or away from the joint). Specific conditions such as gout, septic arthritis, ankylosing spondylitis and diffuse idiopathic skeletal hyperostosis may be considered using the criteria of Rogers and Waldron (1995; 2001).

It is recommended that the different lesions of joint disease should not be "lumped" together to indicate severity, because an increase in the extent of one lesion may not necessarily be paralleled by an increase in extent of another.

A specific bone change in the spine is a *Schmorl's node* (a depression in the vertebral body surface due to intervertebral disk degeneration). This lesion should be recorded at the vertebral level and according to its position on the vertebral surface. Overall, in recording spinal joint degeneration, it is essential to record the specific vertebrae and joints affected, and the individual joint changes.

11.7.3 Metabolic disease

Brickley and Ives (2008) covers all bone changes of metabolic bone disease; see also Mays (2008b).

Cribra orbitalia recording: record presence or absence in both orbits. Many palaeopathologists use the grading system of Stuart-Macadam (1991), but see above regarding "grades of severity".

S*curvy:* consult Ortner and Ericksen (1997), Ortner *et al* (1999)

Rickets consult Ortner and Mays (1998)

Record *osteoporosis* on the basis of spinal compression fractures ("cod fish" vertebrae), plus loss of cortical bone and bone mass (assuming not postmortem); refer to Brickley and Ives (2008) and Agarwal and Stout (2003). Radial (Colles) and neck of femur fractures may also indicate underlying osteoporosis, but can be caused by other factors. Micro-fractures are commonly associated with osteoporosis and can be viewed using light or scanning electron microscopy (Roberts and Wakely 1992).

Harris Lines: record number of lines in anteroposterior radiographs and their extent across the shaft of long bones (distal femur, tibia, and radius are the most useful bones): be aware of the problems of identification and interpretation of Harris lines and that they can resorb with age (Grolleau-Raoux *et al* 1997; Macchiarelli *et al* 1994).

Hyperostosis frontalis interna: consult Barber *et al* (1997)

11.7.5 Endocrine disease

Endocrine disease is a rare occurrence but Resnick (2002) and Ortner (2003) describe changes associated with this category of disease.

11.7.6 Neoplastic disease (see Brothwell 2008, 2012)

The first step should be differentiating whether a lesion is benign or malignant. In many cases the source cell type will be almost impossible to identify. It is recommended that any skeleton with possible malignant changes should be radiographed as fully as possible (see Rothschild and Rothschild 1995 as an example of the value of doing this). The most common conditions are benign ivory osteomas of the skull vault, osteoid osteomas of the long bones, and solitary osteochondromas of long bones.

11.7.7 Dental disease (see Hillson 2008)

Dental disease is probably the condition that has most often been well recorded in British contexts, including the provision of absolute prevalence rates. Lesions/defects should be recorded at the individual tooth level (for caries, calculus, enamel hypoplasia) or tooth position (for periodontal disease, periapical lesions). Information on the numerical coding of each tooth during recording is provided in the BABAO standards. Dental anomalies (e.g. malocclusion) should be recorded following Hillson (2005).

(i) Caries

For carious destruction of teeth the scheme of Lukacs (1989) can be used with the severity of grades (if recorded) of Hillson (2001). The position of the lesion should be based on whether the lesion is on the crown or on the root surface. Coronal caries should be described as occlusal, lingual, buccal/labial or on the interproximal surfaces (mesial or distal), or the cervical (neck) area at the cemento-enamel junction. In advanced caries with gross destruction of the crown, the site of origin cannot be identified. Be careful not to record caries in occlusal surfaces of molar teeth, which may actually be discoloration in the fissures due to soil impaction. Exposure of the pulp cavity can be mistaken for caries, but may also be a complication of caries. What might appear to be periapical lesions on alveolar bone may also be postmortem holes.

(ii) Calculus

The amount of calculus deposit can be recorded following Brothwell (1981) or Dobney and Brothwell (1987), the latter being more detailed (and the former rather subjective but easier to use). However, recording amounts of calculus is subjective. Calculus deposits should also be recorded as supra or sub-gingival. Note the recent advances in analyzing dental calculus (Adler et al 2013; Warinner et al 2014).

(iii) Alveolar disease

The severity of alveolar resorption may be recorded following Ogden (2008:293). Brothwell (1981), also provides a recording system which is again a rather subjective method but relatively easy to use; again "severity" is also a subjective measure. It should be noted that excessive attrition on the teeth stimulates continuing eruption of the teeth (Glass 1981). Therefore, the distance between the alveolar margin and the cemento-enamel junction may not be an accurate reflection of *actual* loss of alveolar bone.

(iv) Enamel hypoplasia (lines, pits and grooves) – see also the FDI system of scoring (Hillson 2005). Recommendations for recording are as follows:

- Type of defect: linear horizontal grooves, linear vertical grooves, linear horizontal pits, non-linear array of pits, single pits (from Buikstra and Ubelaker 1994,56)
- Position: 1 = cusp, 2 = middle section of crown, 3 = neck (crown of tooth divided into three sections by eye), and
- Severity: 1 = just discernible line, 2 = clear groove, 3 = gross defects
- Again, "severity" recording may be subjective
- Hypocalcifications may be recorded as yellow, cream/white, orange or brown and where they are located; post mortem discolouration due to burial in the ground may confuse recording and interpretation To record timing of defect use Reid and Dean (2000), but be aware of the problems of recording and interpretation of the data produced (dental growth data today is applied to archaeological teeth which developed in a different time period, geographic location, and environment; thus, timing of defects according to these data may be flawed).

(v) Periapical lesions (see Ogden 2008 for details of the different types). The location of the drainage sinus of a dental abscess should be described (external, internal or maxillary sinus) and whether or not the lesion is associated with a carious lesion or from pulp cavity exposure due to heavy tooth wear.

(vi) Antemortem dental modifications

Follow the guidelines of Buikstra and Ubelaker (1994, 58).

(vii) Other lesions

Leprogenic odontodysplasia associated with leprosy (see Roberts 1986), defects in teeth associated with congenital syphilis (see Hillson and Grigson 1998).

11.8 Presentation of data and interpretation

The data collected should be presented in tabular and graphical form, and by age and sex, keeping age and sex separate where sample size permits. It is particularly important to provide a table that lists the numbers of each of the individual bones and teeth preserved for observation, and in the case of long bones the segment present available for study, e.g. proximal, mid or distal. Using these data it is then possible to determine absolute frequencies of disease.

Many skeletal assemblages contain fragmentary and incomplete bones, and to maintain consistency in the calculation of frequencies it is recommended that a long bone or articular surface is counted as "present" where two-thirds or more is preserved for examination (see BABAO standards document).

It is acceptable to present data according to the number of individuals affected with the relevant bones or teeth preserved as long as the frequency according to bones/teeth present is also given. It is not acceptable to present frequency of individuals affected for any pathological condition if preservation of the parts of the skeleton relevant for a particular pathological condition (e.g. the spine for tuberculosis) is not accounted for. Summary statistics are also recommended (see English Heritage 2004).

Note that for archaeological populations *prevalence* (proportion of the population at any one time with a specified condition) should be the term applied to frequency rates, and not *incidence* (new cases of a disease in a defined population at risk over a specified unit of time, usually expressed as 10^3 or 10^5) - definitions taken from Waldron (1994).

In the interpretation of the data, age at death and biological sex (where possible) social status, and context, and their influence on the patterns of disease seen should be considered. However, remember that the disease observed may have occurred initially many years before the death of the individual, and therefore correlation of age at death and disease is problematic. Nevertheless, active (woven) new bone formation/unhealed lesions indicate that the disease or trauma that caused the lesions was active at the time of death (perimortem). It is usually not possible to suggest what caused the death of a person through studying their skeletal remains, only what diseases the person experienced through their lives – bioarchaeologists study the skeleton at the point of death and the bones and teeth reflect an accumulation of disease processes throughout that person's life, as seen through the lesions present.

However, most important is a consideration of the data in its cultural context so that explanations can be suggested for the disease frequencies seen. For example, is it a rural or urban site, is the population composed of hunters and gatherers or agriculturists, and do we know what their living environment was like? A consideration of social, economic and environmental factors is essential to understand disease patterning. However, caution should be expressed in

trying to associate skeletal changes with signs and symptoms (everybody will experience a particular disease differently), and impairment (see Roberts 2000), and very close consideration should be paid to Wood *et al*'s (1992) recommendations on inferring health from the skeleton, and how representative the "sample" of skeletons being studied is of the original living population.

On a final note, it is best practice to reference clinical facts with clinical references; palaeopathologists who write palaeopathological papers and books originally retrieved their clinical information form clinical texts. This should be acknowledged as such!

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